Control System of the IHEP Cryo Complex

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The cryo complex was designed to supply the superconducting (SC) Magnet Test Facility (MTF) with liquid helium and nitrogen. The control system is based on IBM/PC's (MS-DOS) and the IHEP version of CAMAC crates. Each crate houses an intelligent controller running a home made operating system and application programs, performing data acquisition and local control functions. A special application program on the console PC's provides a multitask environment under MS-DOS. The programming languages are C on PC and assembler on the crate controller. A hot reserve of electronics (50% of crates) as well as an analog protection system provide a high reliability of controls. Imitators of cryo equipment were designed for the development of modules and applications.

The cryo complex is a part of the SC MTF for the UNK project [1]. It consists of the central liquifier, 10 satellite refrigerators, 2 compressors, the purification system and transfer lines. The liquifier incorporates a liquid nitrogen precooling system, 2 turbine expanders and a wet expander.

Stopped reading as paper carries on in the same way. The cryo complex was the first one in the Soviet Union to work under computer control. It was suggested to operate without personnel. Subsequently a few similar complexes distributed along the 21 km UNK tunnel were installed to operate only under computer control, without any personnel. Therefore the construction of the cryo complex aimed to not only provide the SC MTF with liquid nitrogen and helium, but also to develop and to test the cryo equipment and the control system itself. That stipulated features of the controls approach:

- preliminary testing of control modules and application programs using specially designed imitators for generating status and parameter inputs of the cryo equipment (temperature, pressure, level and consumption of liquid, valve position and so on)
- 100% "hot" reserve of interface electronic crates;
- analog electronics protection system to prevent destroying of the cryo equipment in case a break-down of computer controls;
- "step by step" execution of more than 100 application programs of the unclosed loop algorithms for better human control of the equipment behavior (startup and stopping of the equipment, interlocks, etc.).

The autonomous analog protection system supervises the most critical parameters such as turbine expander rotation frequency, pressure at vessels, level of cryo products, temperature of heat exchangers and so on. It detects differences between preset and measured parameters. The system uses the same pickups and actuators as the computer control system.

A control system provides surveillance of about 900 signals, management of 130 closed loops and other control functionality.

A schematic view of the computer control system is given below. The architecture of the control system is based on a two level distributed computing system. The upper level uses MS-DOS IBM PC′s linked by Ethernet. Every PC manages one group of equipment such as compressors, vacuum system etc. The console functions are realized on the same PC′s.

The lower level is a set of equipment controllers (EC) in an IHEP version of CAMAC crates. Each PC is linked by RS-232 to several EC′s. The communication protocol provides the recognition of faults during data exchange and the repetition of erroneous transfers thus excluding the loss of information. The EC includes:

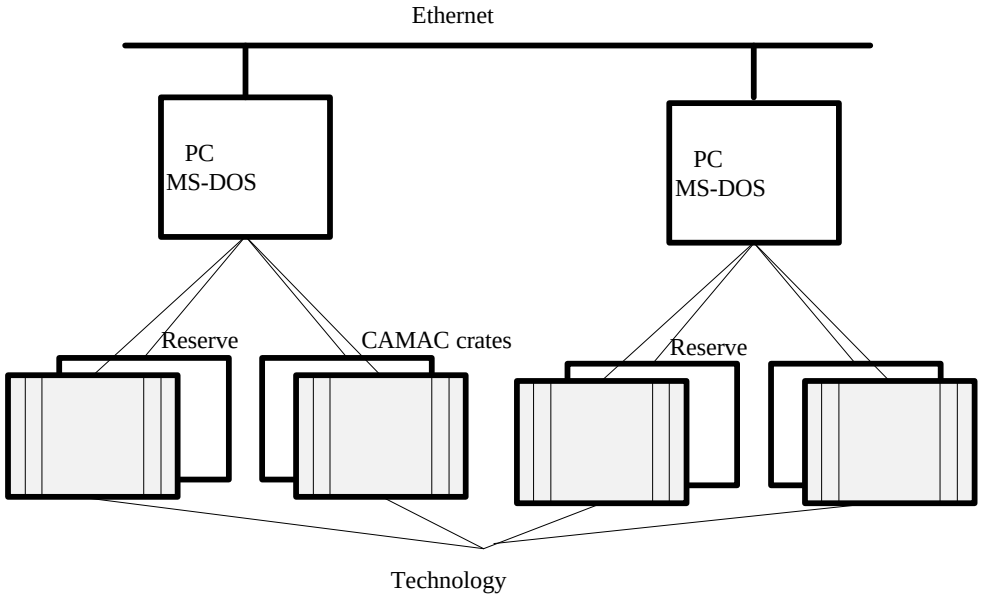
- intelligent crate controller based on a 16 bit LSI-11 compatible processor;
- intelligent (16 bit, LSI-11 compatible) modules for 4 control loops aimed to provide the reliability of the control system as well as of the cryo complex;
- converters for the Allen-Bradley thermometers;
- 12 bit ADCs;
- I/O registers;
- restart memory (after failure/restore) module;
- thyristor and relay actuators for motors and valves.

In order to implement the software for consoles we developed a special monitor under MS-DOS which allows to organize a multitask environment, in particular to have access to several microprocessors simultaneously. The descriptions of equipment parameters are placed in a data base. A specific software is generated for each of the equipment groups, taking into account the relevant parameter descriptions from the data base version (including upper and lower levels). This approach guarantees the information integrity of software for both levels.

The main functions of the software for the consoles are: acquisition and processing of data from EC′s, presentation of data as tables, graphics and charts, remote control of processes, delivery of alarm messages to the operator, protection and interlock of equipment, archiving.

The reserve EC′s are also linked to the console PC′s. The operator can activate them replacing in such manner the broken EC′s.

The software in the EC consists of a local problem oriented OS (home made) and a set of applications for data acquisition, initial processing and processing of data from



pick-ups for protection of equipment and interlocks, for step by step execution of control algorithms and for exchange of information with PC′s. For step by step execution of programs a problem oriented programming language was created as macro extension to MACRO-11. Cross compilers and relevant emulators were created on PC to develop and test the software for EC′s.

Despite the shortage of funding did not permit comprehensive testing of the whole cryo complex, the control system proved its reliability and provided commissioning of the cryo complex equipment and the liquid helium production under computer controls.

The author list of this status report contains only names of group leaders. In fact many more people took part in the design and implementation of the control system.

References

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